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Determination of Selected Material Properties of Castable Thin Film Polyimides for Applications in Solar Thermal Propulsion

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This Study Will...

- Provide an Introduction to Typical Applications of Thin Film Polyimides
- Introduce 6FDA + APB Polyimides as an Important Component in Solar Thermal Propulsion
- Show Unique Methods in the Determination of Selected Material Properties of 6FDA + APB Polyimides
- Provide Modulus of Elasticity and Coefficient of Thermal Expansion Data for 6FDA + APB Polyimides

What is a Thin Film?

- Thin Sheet of a Polymer Material
- Typically .0005 - .002 Inches Thick
- Used for Stretched Membrane Mirrors and Parabolic Concentrators
- Examples of Thin Film Materials
  - Mylar™ Polyester Film
  - Kapton™ Polyimide Film
  - 6FDA + APB Polyimide Film

An Application of Thin Film Polyimides

- Solar Thermal Propulsion is Fast Becoming an Attractive Option for On-orbit Satellite Maneuvers
  - LEO to GEO Orbit
  - High Performance (Typical Isp – 600 - 1000 sec.)
  - Lightweight
- The Components of a Solar Powered Rocket Include...

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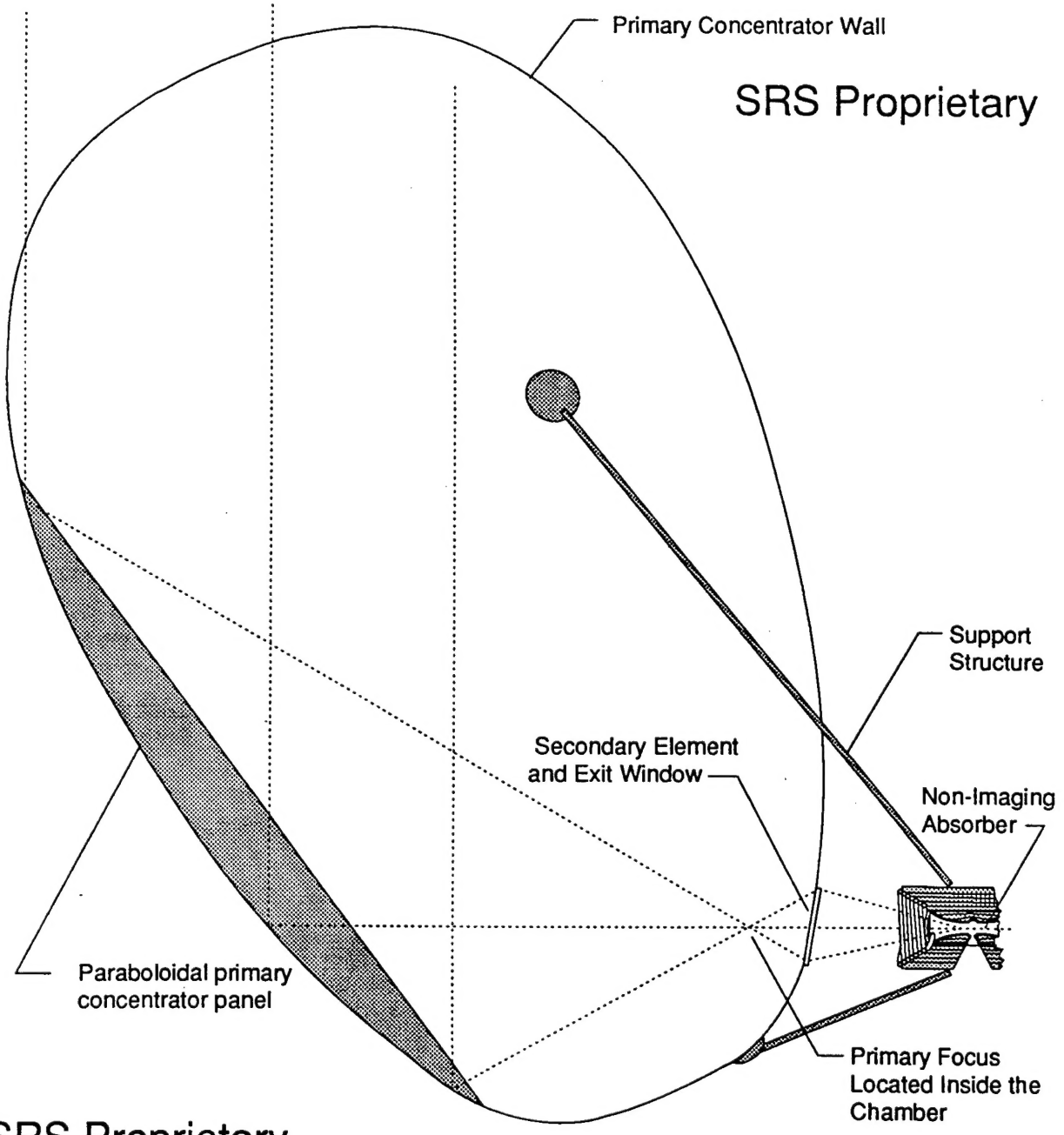
Typical Solar Thermal Rocket Configuration



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Benefits of 6FDA + APB Thin Films

- Lightweight
- Optically Transparent
- Stowable / Deployable
- Superior Material Properties
- Wide Temperature Range (-450 – 750°F)
- Castable on Curved Surfaces

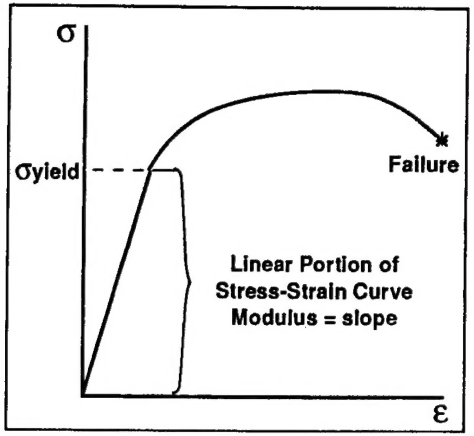
Design Parameters for Articles Constructed with Thin Film Polyimides

- External Loads / Pressures
- Environmental Conditions
- Transparency
- Material Properties
  - Modulus of Elasticity
  - Coefficient of Thermal Expansion
  - Coefficient of Moisture Expansion
  - Poisson's Ratio

Theory

- Modulus of Elasticity (Young's Modulus) is given by Hooke's Law

$$\sigma = E\varepsilon \quad \text{(psi)}$$



- Coefficient of Thermal Expansion is given by

$$CTE = \frac{\Delta L}{L \Delta T} \quad \text{(in/(in°F))}$$

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Thin Film Test Apparatus

- Conforms to ASTM Standards
- Includes Temperature Chamber
- Provides Constant Uniform Loading
- Incorporates Unique Toggle Grip Design
- Computer Data Acquisition System

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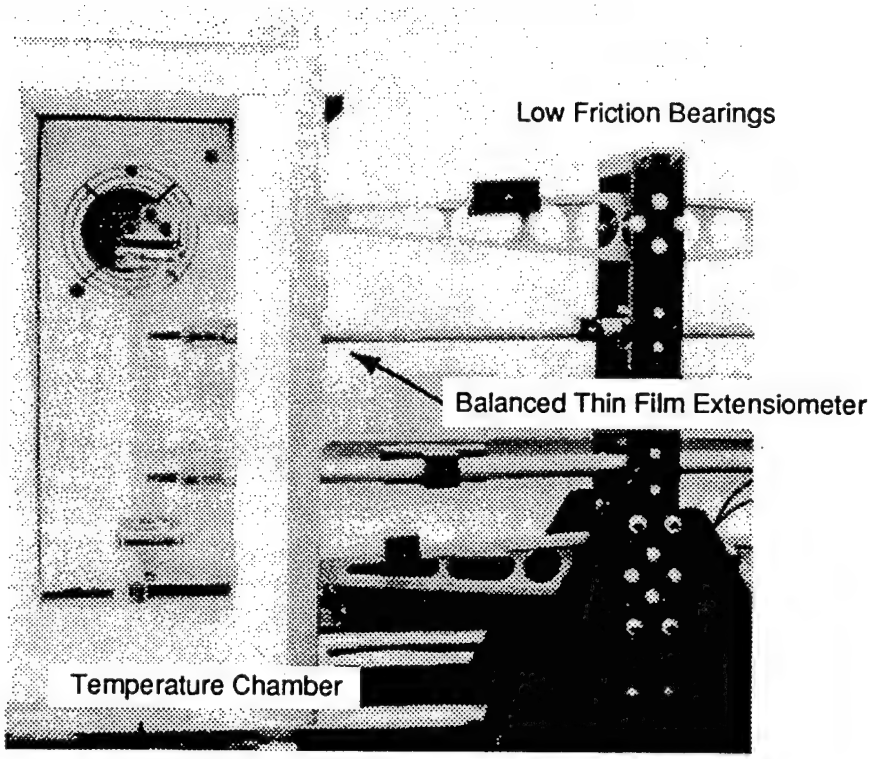
Uniaxial Test Appartus



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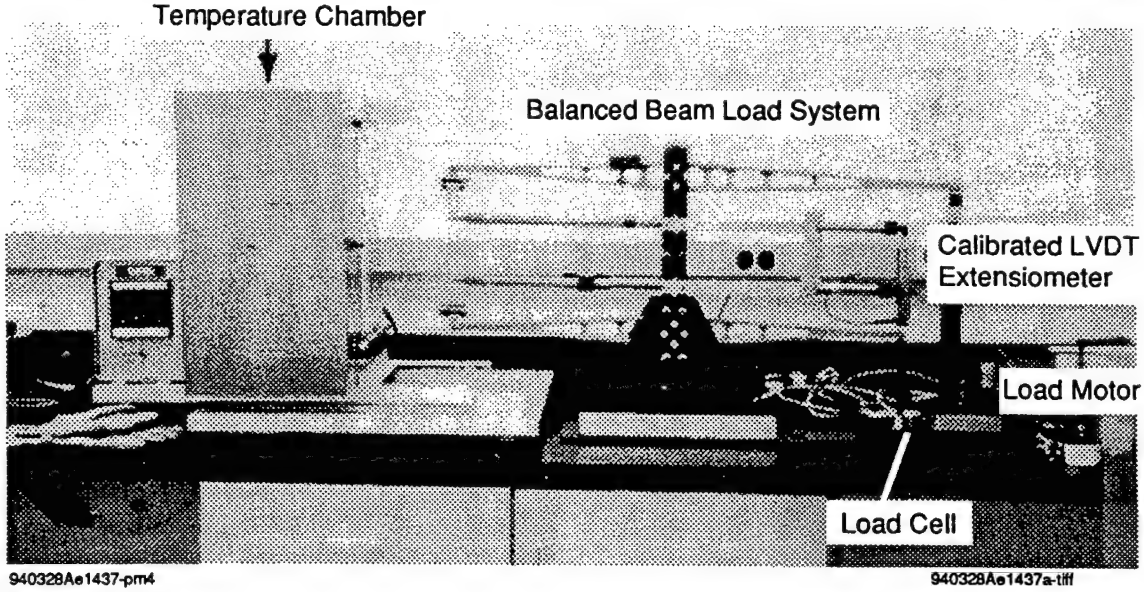

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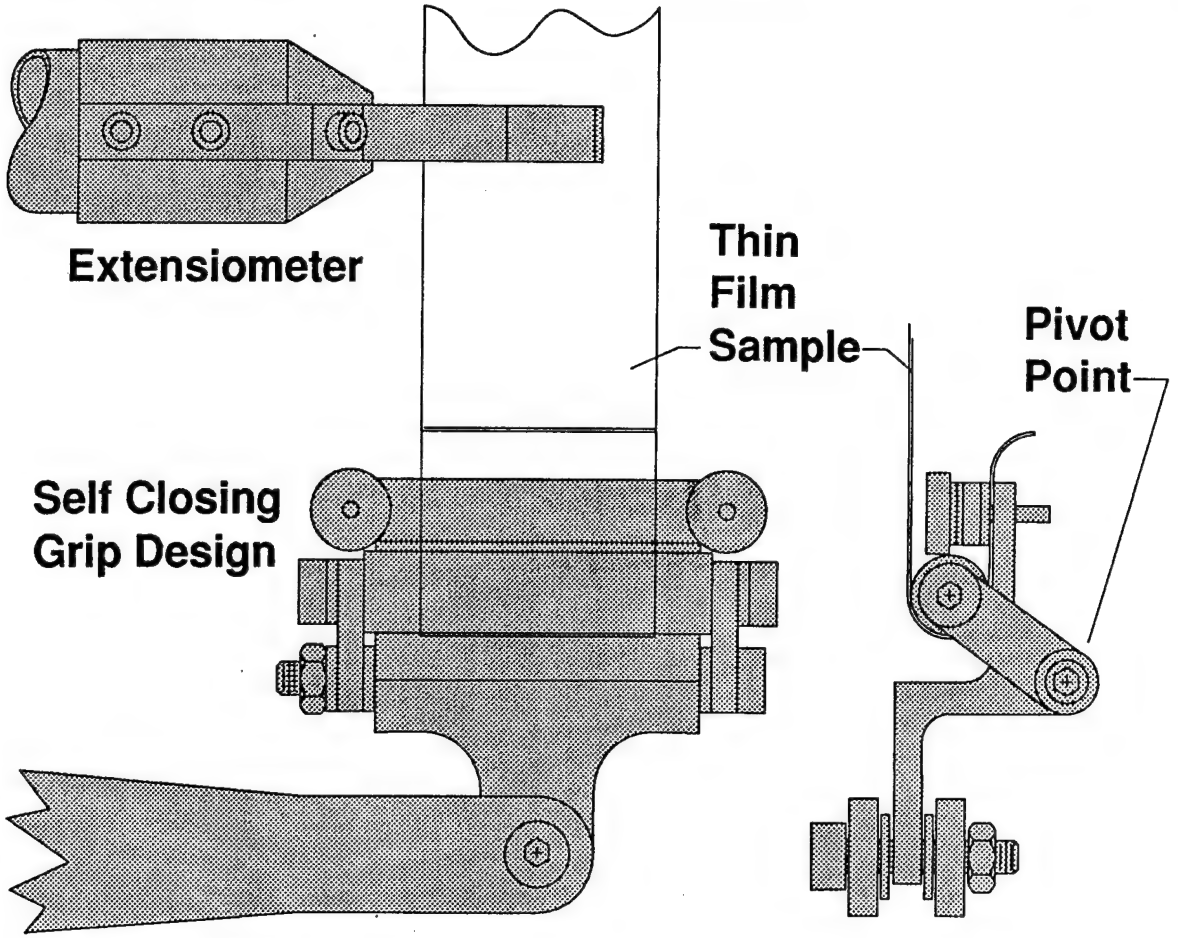
Toggle Grip Design



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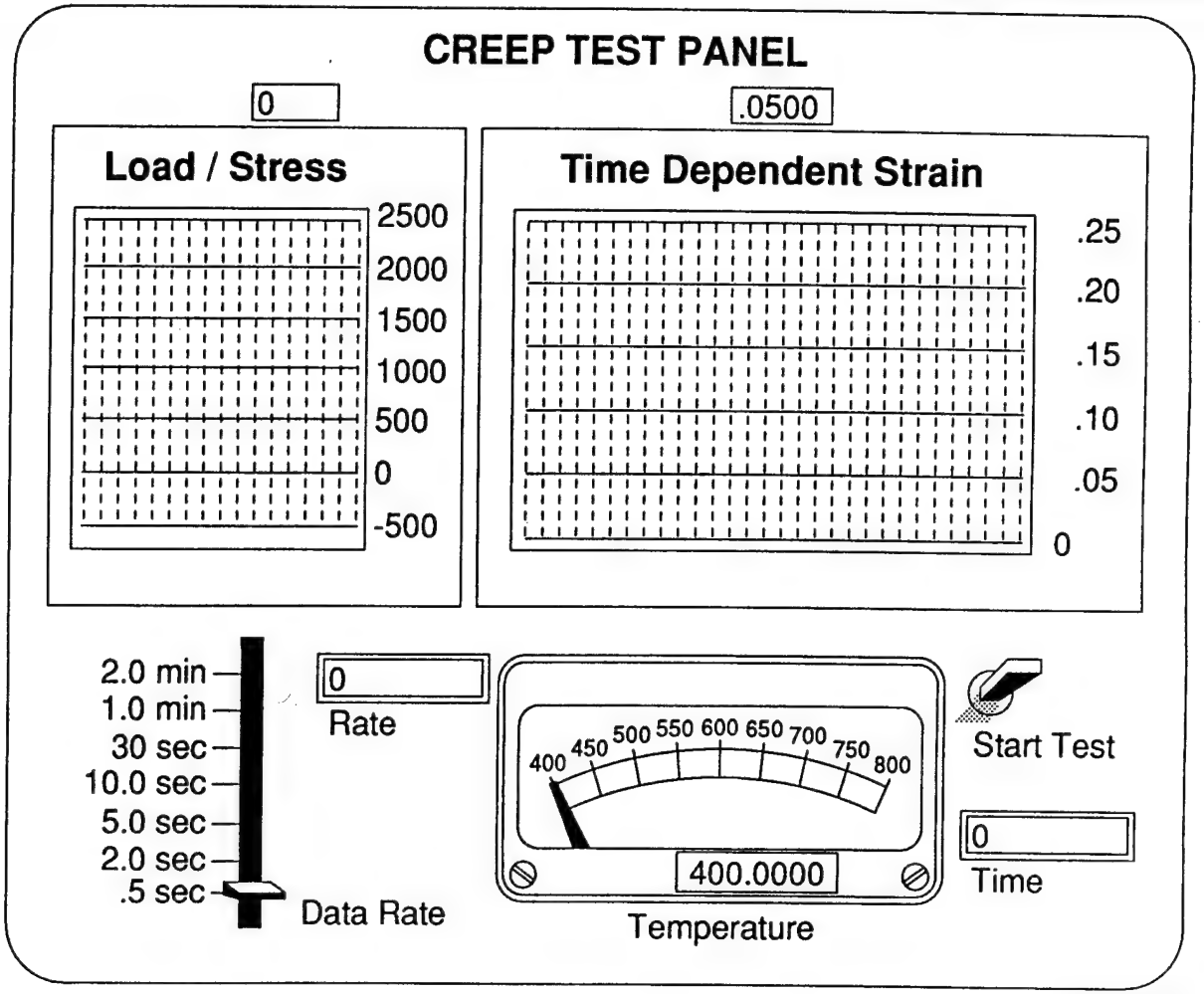
Computer Test Panel



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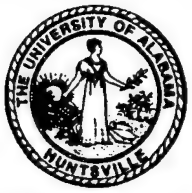
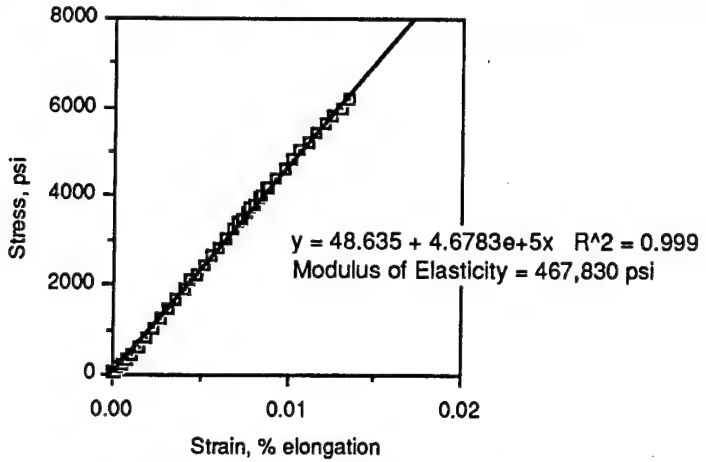


Experimental Procedure

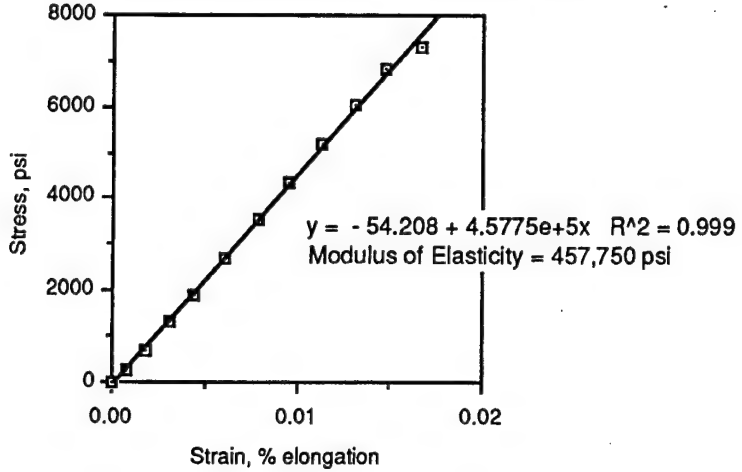
- Cast, Cut and Measure Samples
- Material Tester Calibration
- Perform Modulus Tests on Kapton Polyimide
- Perform Modulus Tests on 6FDA + APB Polyimide
- Perform CTE Tests on 6FDA + APB Polyimide
- Tabulate and Graph Results
- Compare Results to Material Source Data

Modulus of Elasticity Results

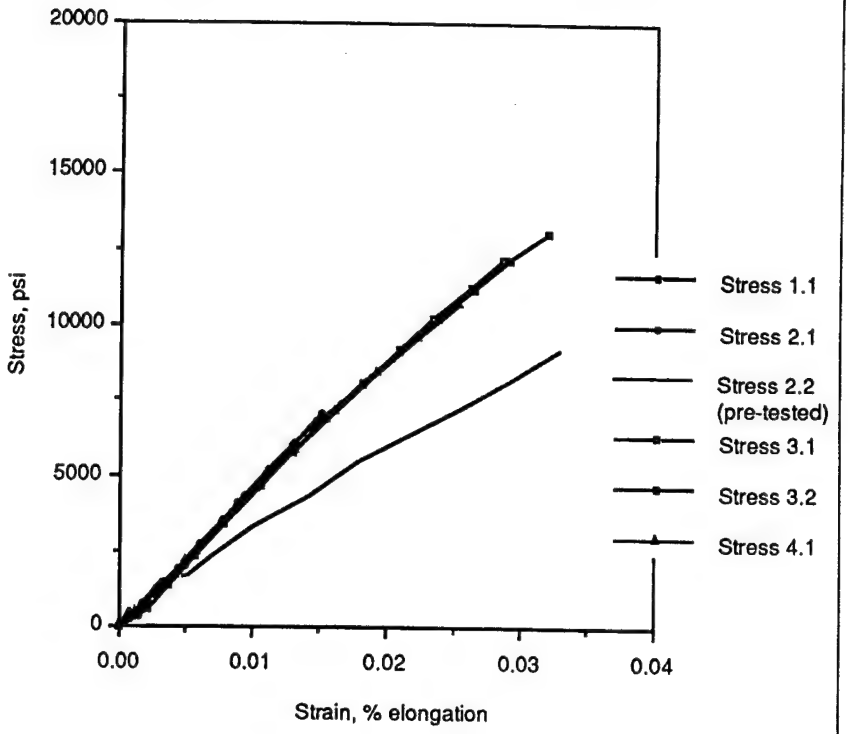
.5 mil Kapton Type H Linear Curve Fit



6FDA+APB Polyimide Linear Curve Fit



Comparison of Stress vs. Strain Curves for the 6FDA+APB Polyimide



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Modulus of Elasticity Results cont.

	Manufacturer's Data	Harris / NASA	Results of Tests	% Difference
Kapton Type H	430,000 psi 1 mil at 25 °C		467,830 psi .5 mil at 23 °C	8.8 %
6FDA + APB		426,000 psi 452,000 psi	457,500 psi 457,500 psi	7.5 % 1.3 %

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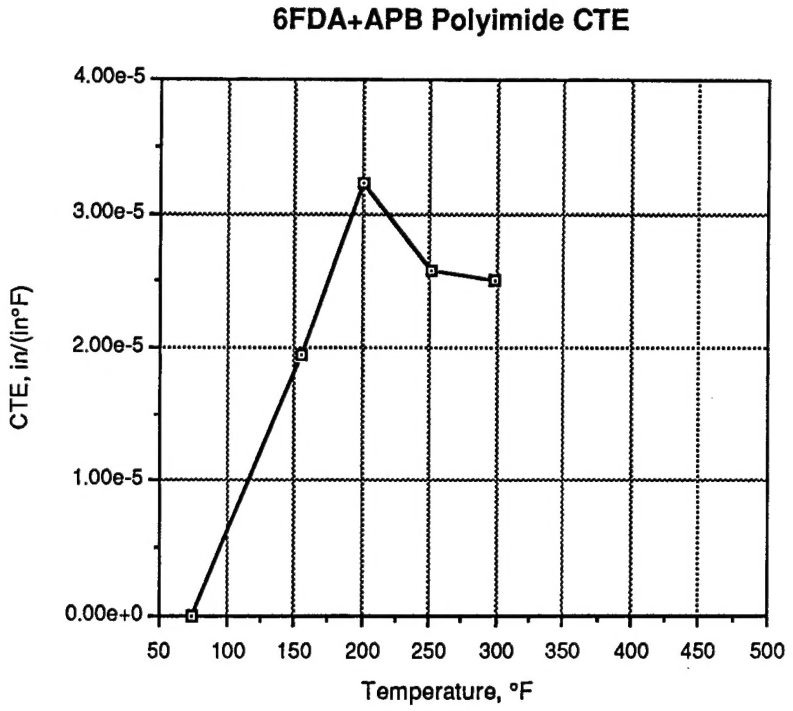
Coefficient of Thermal Expansion Results



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Coefficient of Thermal Expansion Results cont.

	Harris Data	Results of Tests	% Difference
Average CTE	27.2E-6 in/(in°F)	25.7E-6 in/(in°F)	5.7%

Conclusions and Recommendations

- All Tests Showed Good Repeatability
- Results Compared Favorably to Source Data
- Values Presented here may be used as Design Parameters for Applications of Thin Films in Solar Thermal Propulsion
- The Determination of other Material Properties is Recommended
- Furthur Investigation of the Non-linearity in the CTE Curve is Recommended

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